SNS DTL D-Plate Beam Stop Overview

March 14, 2002

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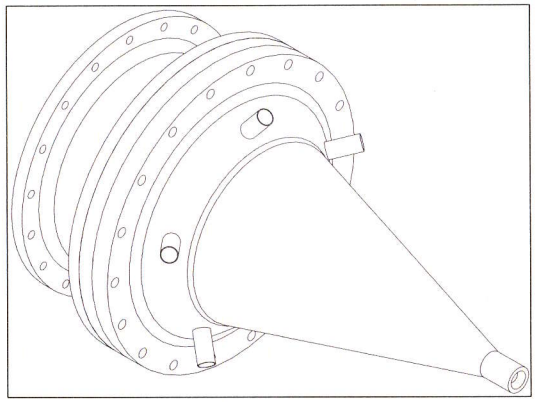
SNS-03

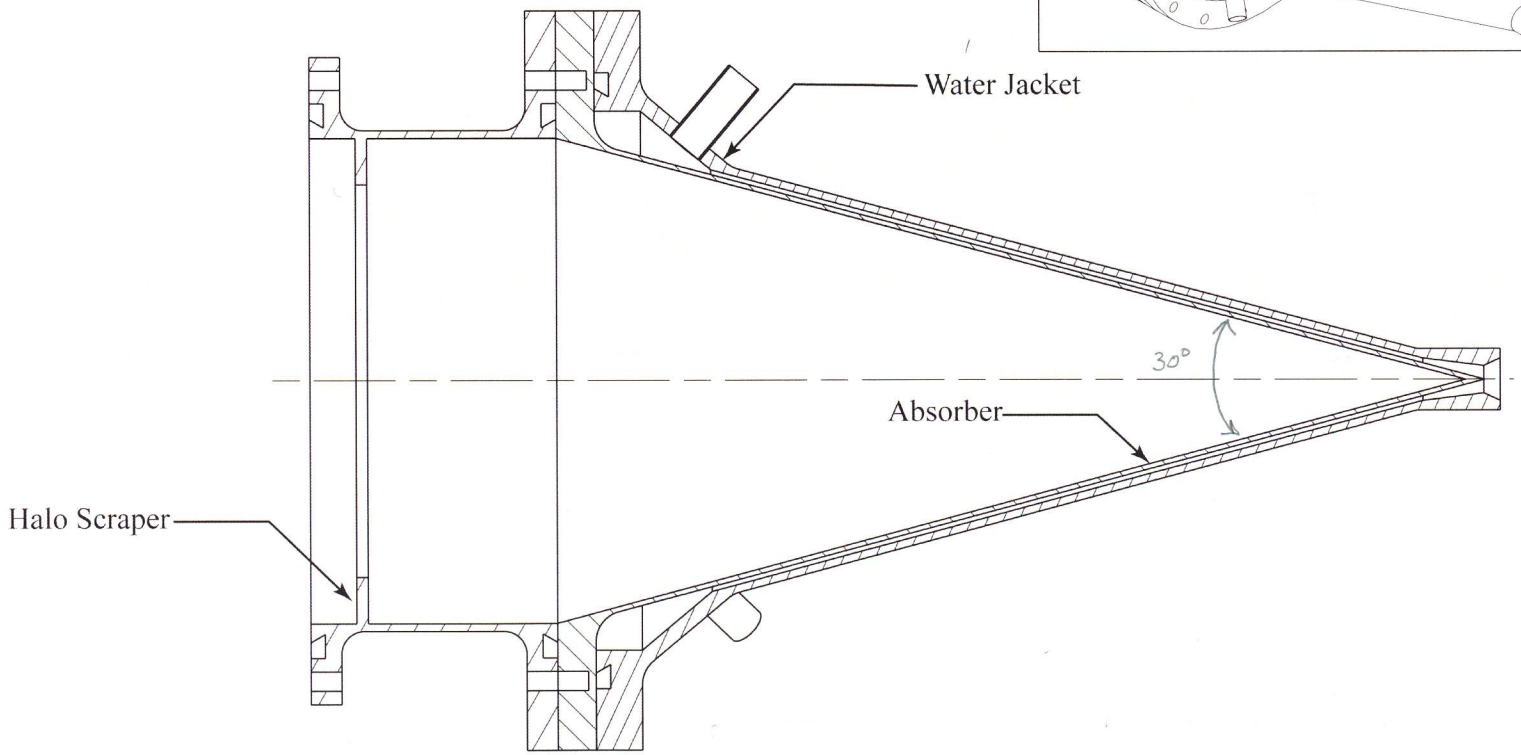
General Requirements

- **Accommodate two D-plate beam profiles**
  - Full power but expanded beam from DTL tank #1, 26-mA, 1.0-ms pulse, 60-Hz, 11.7-kW
  - Emittance tune beam, reduced duty, 26-mA, 50-μs pulse, 10-Hz, ~100-W
- **Stop 7.5-MeV protons**
- **20-cm aperture**
- **Minimum activation**
  - Material selection
- **Beam diagnostics**
  - Beam current measurement
  - Segmented halo scraper
- **Limited term use**
  - 2 shifts per day for 90 days (conservative)
- **Conventional cooling scheme**
  - Single phase, low pressure, water
  - Borrow existing DTL cooling package
- **Minimum risk**

Beam Stop Assembly

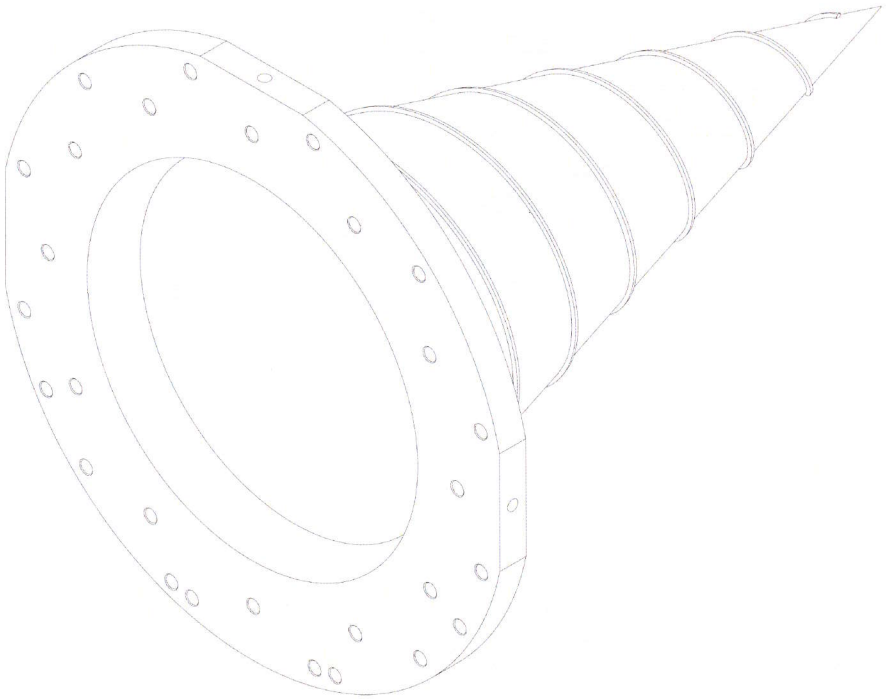
- 3 detail components:
  - Absorber
  - Water jacket
  - Halo scraper
- Bolted assembly, easy inspection
- Viton o-ring seals, ¼-in diameter
- No water to vacuum seals or braze joints
- water cooled, integral manifolding





Absorber

- Nickel 201
- Machined from forging or cold worked bar stock
- 30° included angle conic
- 20-cm aperture
- 2.0-mm thick
- Spiral flow divider welded or low temp brazed
- Joints EB welded, radiograph inspection
- Helicoil threaded inserts
- Primarily lathe machining



Nickel 201

- **Commercially pure nickel**
- **Nominal thermal properties:**

Parameter	Quantity
density	8.89-gm/cc
specific heat	456-J/kg-K
thermal conductivity	79.3-W/m-K

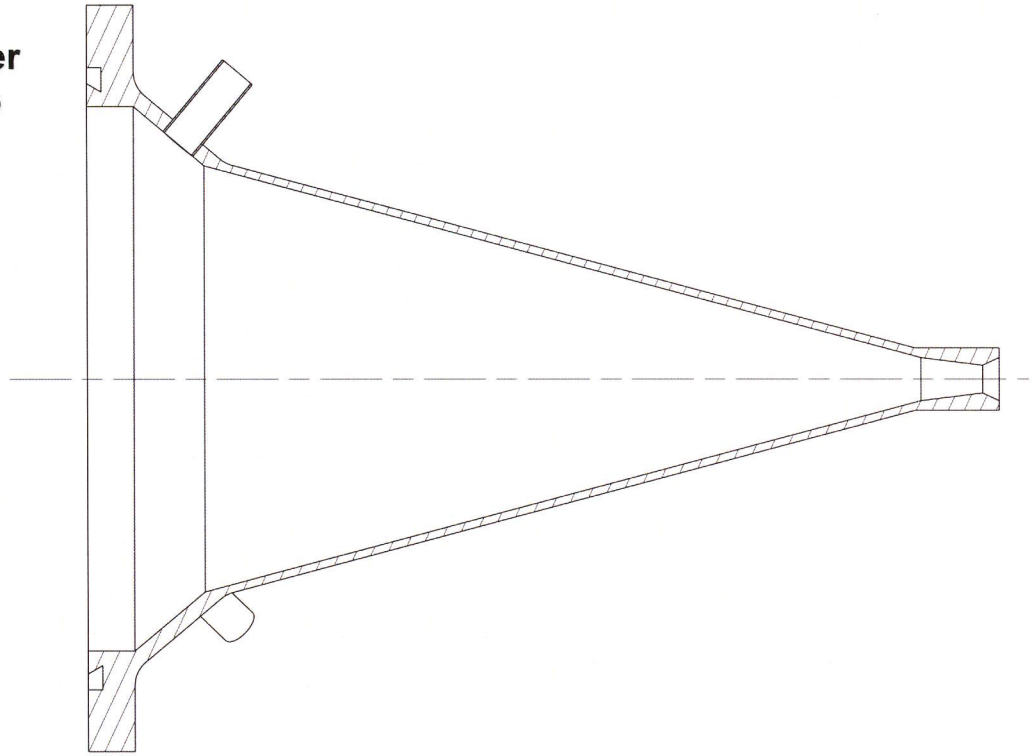
- **Nominal mechanical (cold worked) properties:**

Parameter	Quantity
Young's modulus	30e6-psi
CTE	7.3-μstrain/°F
yield strength	35-90 ksi
tensile strength	60-100 ksi
elongation	35% – 10%

- **Sufficient fatigue properties**
- **Fabrication ease**
  - Welding & Machining
- **Corrosion resistant**
  - Vacuum & cooling system compatible
- **Preferred material concerning activation**
  - Low neutron yield for 7.5-MeV protons (LEDA data)

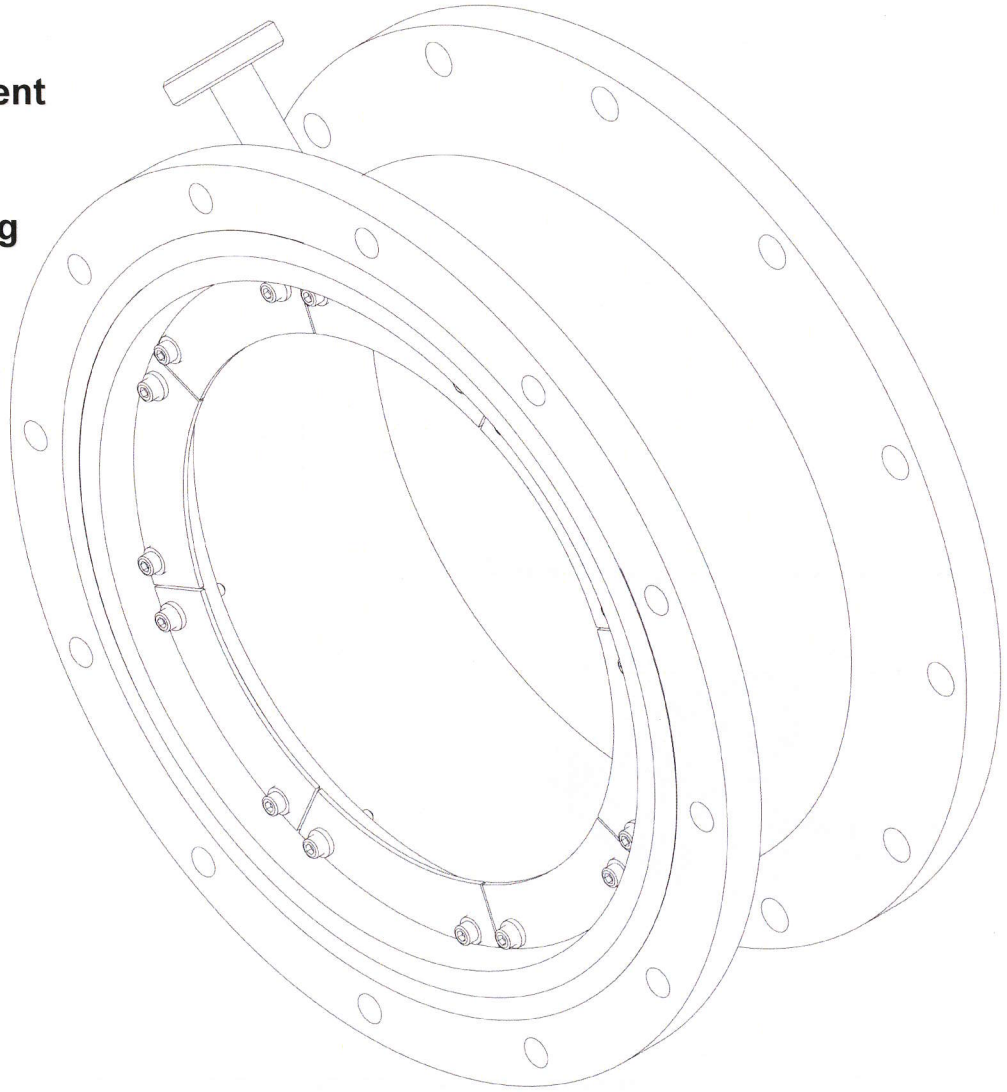
Water Jacket

- 304L weldment
- Nests over absorber
- Conventional TIG or MIG welding
- Nominal 1/8-inch wall
- Integral nozzle at inlet to maintain proper flow velocity over absorber tip
- Passivated
- Heat treat/annealing not necessary
- Primarily lathe machining



Segmented Halo Scraper

- 8 segments
- Allows measurement of beam halo current
- 16.0-cm aperture
- 0.063-in thick nickel segments or petals
- Macor segment insulators, kapton wiring
- DB-9 vacuum feed through connector
- 304L stainless steel spool piece
- Passivated

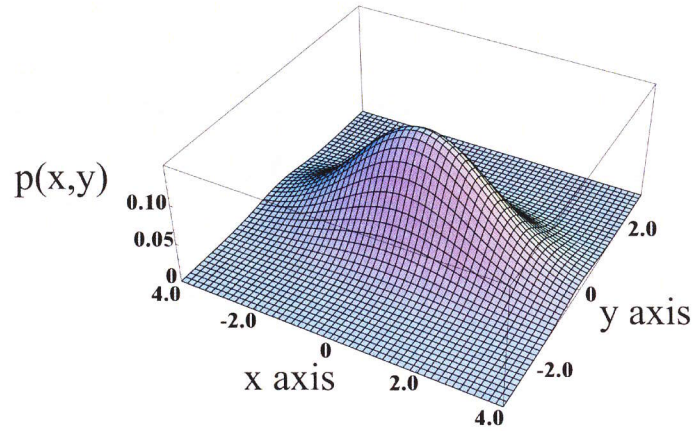


Beam Heating

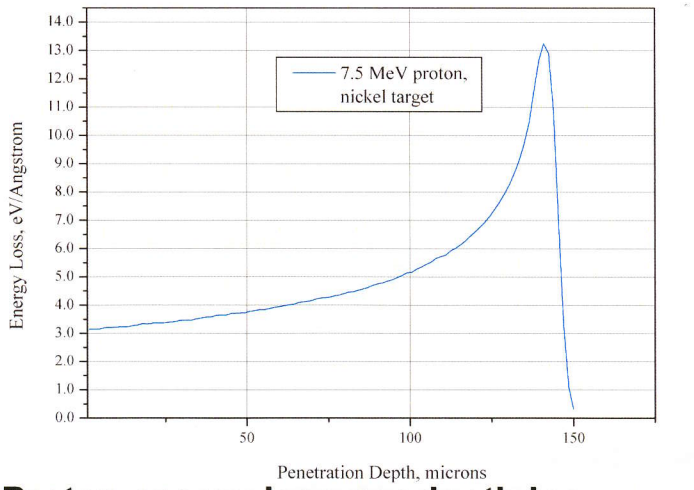
- **Energy deposition due to proton kinetic energy loss**
- **7.5-MeV H^- ions, 26-mA**
- **50-ms to 1-ms pulse durations**
- **Repetition rates up to 60-Hz**
- **3-D spatial energy deposition**
  - Bi-Gaussian transverse beam distribution

$$p(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{\left(\frac{-x^2}{2\sigma_x^2}\right)} e^{\left(\frac{-y^2}{2\sigma_y^2}\right)}$$

  - Depth dependant energy loss



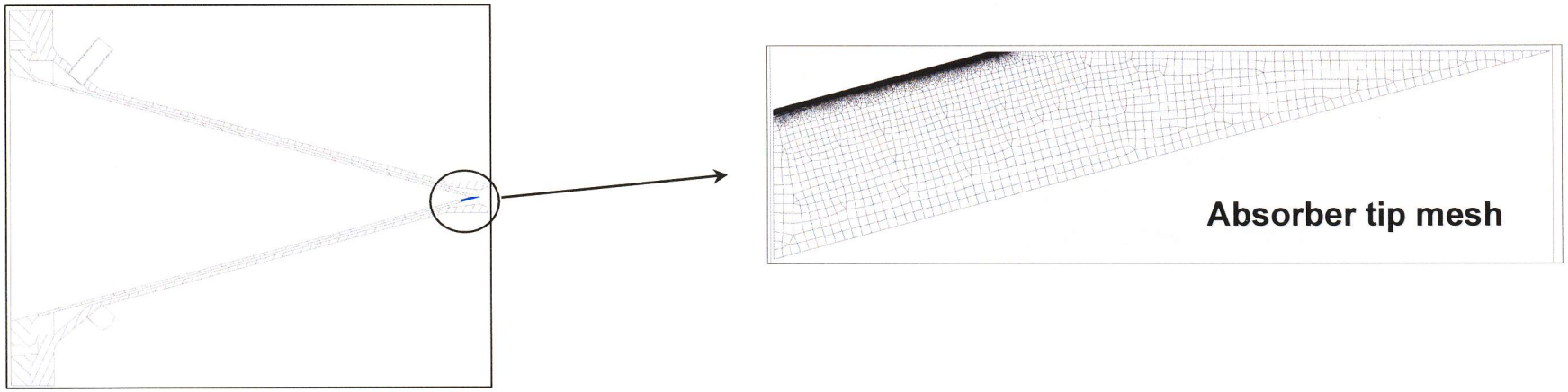
Bi-Gaussian beam density plot



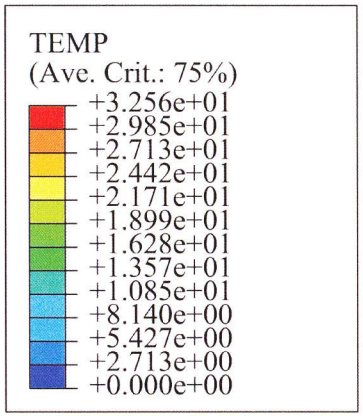
Proton energy loss per depth increment

Thermal & Structural Analysis

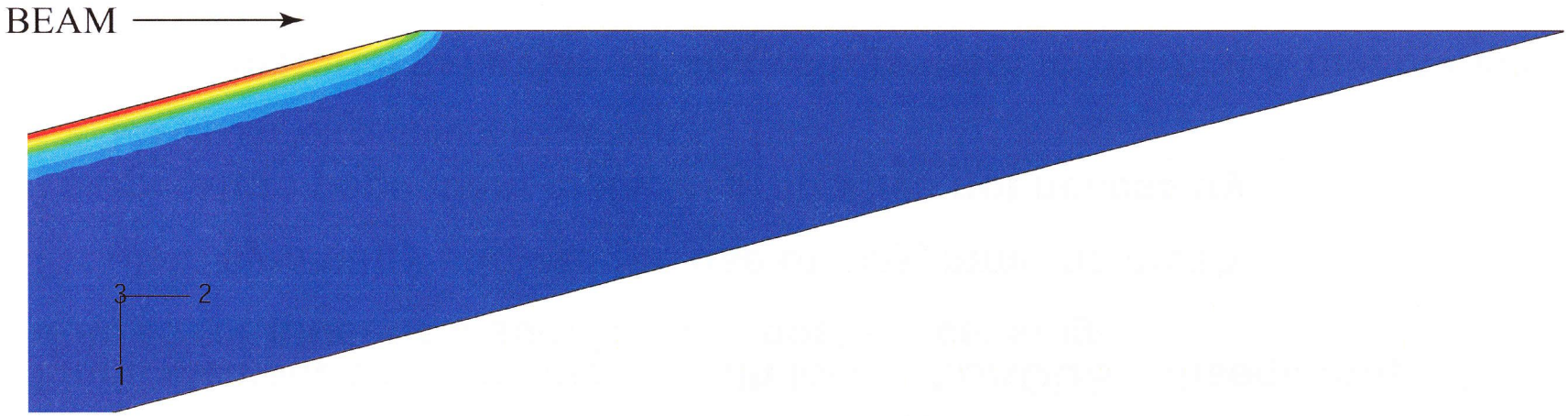
- **Finite element mesh generated with Ideas, ABAQUS subsequently utilized for numerical solution and post processing**
- **Problem symmetry allowed the use of axisymmetric mesh**
- **Temperature dependant material properties not necessary**
  - Maximum temperature excursion < ~100 K
- **Isotropic material behavior utilized with respect to thermal & mechanical properties**
- **Accurate spatial body heating due to beam impingement applied to mesh with FORTRAN subroutine**
  - Function of x, y, z, σ_x, σ_y, penetration depth, beam current, energy
  - Requires very fine mesh to accurately capture behavior near Bragg peak



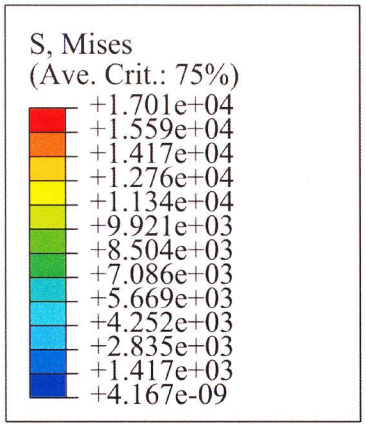
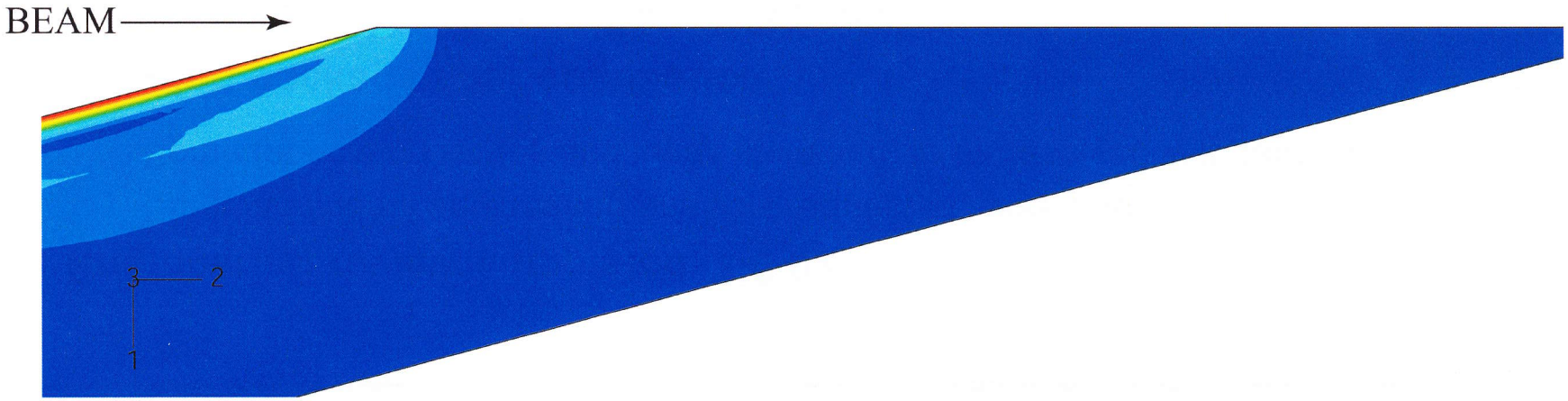
Full Power Beam
Absorber Transient Thermal Response



- Absorber tip axisymmetric model
- 11.7-kW full power beam
- 1.0-ms pulse
- 2.0-cm RMS beam size
- Spatial body heating
- Calculated temperature rise, Kelvins



Full Power Beam
Absorber Transient Thermally Induced Stress



- Absorber tip axisymmetric model
- 11.7-kW full power beam
- 1.0-ms pulse
- 2.0-cm RMS beam size
- Spatial body heating
- Calculated thermally induced von Mises Stress, psi